State of Hawaii
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Aquatic Resources
Honolulu, Hawaii 96813

April 28, 2006

Board of Land
and Natural Resources
Honolulu, Hawaii

THE DIVISION OF AQUATIC RESOURCES REQUESTS BOARD OF LAND AND NATURAL RESOURCES (BLNR) AUTHORIZATION/APPROVAL TO ISSUE ONE (1) NORTHWESTERN HAWAIIAN ISLANDS (NWHI) RESEARCH, MONITORING AND EDUCATION PERMIT TO DR. CARL MEYER OF THE HAWAII INSTITUTE OF MARINE BIOLOGY FOR 1) THE CAPTURE, TAGGING, AND RELEASE OF APEX PREDATORS, AND 2) DEPLOYMENT AND DOWNLOADING OF ACOUSTIC RECEIVERS

Submitted herewith for your authorization and approval is a request for issuance of a NWHI Access Permit to Dr. Carl Meyer of the Hawaii Institute of Marine Biology (HIMB), University of Hawaii. The Research, Monitoring and Education Permit, described below, will allow activity to occur in the NWHI State marine Refuge (0-3 miles) waters surrounding Nihoa Island, French Frigate Shoals, and Gardner Pinnacles. The activities covered under this permit will occur from May 18 to June 11, 2006, from the support vessel Hi'ialakai. Ship details are provided with Item F-4.

Top predators play a keystone role in the Northwestern Hawaiian Islands ecosystem. In the NWHI, this role is filled by sharks and large teleost fishes. Empirical data on top predator movements will be valuable for developing appropriate management strategies for these ecologically important animals. The researchers propose to answer three questions relevant to management zoning: (1) Do top predators move across open ocean between atolls?, (2) How extensive are their intra-atoll movements?, and (3) Do top predators exhibit predictable patterns of movement and habitat use? These questions are directly pertinent to management of NWHI resources.

The proposed activities (below) are consistent with and support the purposes of the Refuge, primarily to better understand and manage the resources within the marine refuge.

a) Deployment of underwater receivers at Nihoa and Gardner Pinnacles: Meyer et al. will create two temporary receiver moorings to record the presence of acoustic transmitters implanted in top predators. They will create these moorings in areas of soft sediment and inert substrate, avoiding live corals. These moorings have been tested and proven to withstand high surf. The moorings will be removed when monitoring has been completed. Underwater receivers will be anchored to the moorings and will record the presence of any acoustic tag within 500m.

b) Deployment of transmitters: Meyer et al. will tag four species of top predator with acoustic and satellite transmitters. The species of interest are *Galeocerdo cuvier*, tiger shark; *Carcharhinus amblyrhynchos*, gray reef shark; *Triaenodon obesus*, whitetip reef shark, and *Aprion virescens*, grey snapper. They will collect sharks and snapper by trolling with artificial lures, handlining with a single baited hook, or via bottom set 6 hook line for large sharks. Acoustic transmitters are surgically implanted through a small incision which is then sutured closed. Satellite transmitters are attached via small bolts through the dorsal fin, or via titanium-steel darts inserted under the skin at the base of the dorsal fin. After transmitters are attached, the animal is released, and the entire process takes less than 10 minutes. Meyer et al. propose to tag 10 tiger sharks (at Nihoa and FFS), 7 gray reef sharks (at Nihoa and FFS), 10 whitetip reef sharks at FFS, and 10 grey snapper at Nihoa.

c) Data retrieval, reduction, and analysis: Meyer et al will retrieve and download data from 5 underwater receivers already in place at French Frigate Shoals.

REVIEW PROCESS:

The permit was received by the Division of Aquatic Resources on Monday, March 6, 2006. It was sent out for review and comment to the following scientific entities: Division of Aquatic Resources staff (5), Division of Forestry and Wildlife, Northwest Hawaiian Islands Reserve, United States Fish and Wildlife Service. Native Hawaiians from the Office of Hawaiian Affairs, and Kaho'olawe Island Reserve Commission were also consulted.

Comments received from the Scientific Community (DAR and the NWHI Reserve) are summarized as follows:

1. Two reviewers requested further information about how stress and mortality of apex predators would be avoided/minimized.
2. One reviewer expressed concern regarding the materials used in, and placement of, receiver moorings

Comments received from a Native Hawaiian are summarized as follows:

1. There was concern regarding the take of grey snapper, in that tracking this commercially important species might reveal habitat data that could be exploited by commercial interests.
2. There was concern for native Hawaiian intellectual property rights for new discoveries and the protection of the resources for their potential product developments.

RESPONSE:

A meeting of DAR staff and HIMB researchers was held on 12 April 2006 to address concerns, and a synopsis of the response to concerns raised was as follows:

1. Apex predator survival rate in previous studies has been 100%, and all possible means are taken to minimize stress to captured animals. Heavy fishing gear is sed in order to ensure rapid retrieval and processing. As the researchers intend to track these animals, ensuring their well-being and survival is paramount.
2. No anti-fouling paints of any kind are used, and no lead. Metallic components are coated, and live substrates are avoided. The most common installation is a sand-screw installed in soft bottom, and the receiver array is small enough to ensure that it does not pose an entanglement hazard to marine turtles or monk seals.
3. Consensus was reached during the discussion that tracking of small numbers of grey snapper in the NWHI was unlikely to reveal location data that wasn't already known to fishing enthusiasts.
4. The Guidelines for Submitting Permit Applications stipulates that, for all permits, the activity must be non-commercial and will not involve the sale of any organism, byproduct, or material collected. Furthermore, the Guidelines state that resources and samples are a public trust, and are not to be used for sale, patent, bioassay, or bio-prospecting, or for obtaining patents or intellectual property rights. This condition will be added to the Permit Terms and Conditions for this, and all future permits. This should address the concerns raised by the Native Hawaiian reviewers.

AMENDMENTS REQUESTED SUBSEQUENT TO APPLICATION SUBMISSION:

Dr. Meyer requested via email on April 14, 2006 that, in the event that his target sample size of sharks is not reached at FFS, he be allowed to capture animals in the waters surrounding Gardner Pinnacles to achieve his intended sample size. He provided an amended species table (attached), to replace the table in his Permit Application, item 8c.

FINAL STAFF RECOMMENDATIONS:

1) Approve the request for the capture, tagging and release of the following apex predators in the numbers and locations proposed, as follows: 10 tiger sharks (at Nihoa, FFS or Gardner), 7 gray reef sharks (at Nihoa, FFS, or Gardner), 10 whitetip reef sharks at FFS or Gardner, and 10 grey snapper at Nihoa.

2) Approve the request for the deployment, recovery, and redeployment of acoustic receivers and requisite moorings in State waters of the NWHI.

RECOMMENDATION:

"That the Board authorize and approve, with stated conditions, a Research, Monitoring and Education Permit to Dr. Carl Meyer of the Hawaii Institute of Marine Biology, for activities and access within the State waters of the NWHI."

Respectfully submitted,

DAN POLHEMUS
Administrator

APPROVED FOR SUBMITTAL

PETER T. YOUNG
Chairperson

(c) Collection of specimens – collecting activities (would apply to any activity): Organisms or objects (List of species, if applicable, add additional sheets if necessary):

Common name	Scientific name	No. & size of specimens	Collection Location(s)
Tiger shark	*Galeocerdo cuvier*	10 (2.5-5 m Total Length)	FFS, Nihoa, Gardner
Gray reef shark	*C. amblyrhynchos*	7 (1.2 – 2.4 m Total Length)	FFS, Nihoa, Gardner
Whitetip reef shark	*T. obesus*	10 (1.0-1.7 m Total Length)	FFS, Gardner
Grey snapper	*Aprion virescens*	10 (0.5-1.2 m Total Length)	Nihoa

APPENDIX 1

State of Hawai'i
DLNR
Northwestern Hawaiian Islands State Marine Refuge
Permit Application Form

For Office Use Only
Permit No:
Expiration date:
Date Appl. Received: 3/6/06
Appl. Fee received: N/A
NWHI Permit Review Committee date:
Board Hearing date:
Post to web date:

Type of Permit

X I am applying for a **Research, Monitoring & Education** permit. (Complete and mail Application)
X This application is for a NEW project in the State Marine Refuge.

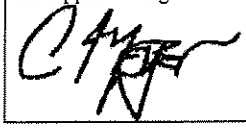
When will the NWHI activity take place?
X Summer (May-July of **2006** (year)
Note: Permit request must be received before February 1st
Specific dates of expedition **May 18 – June 9, 2006**

NOTE: INCOMPLETE APPLICATIONS WILL NOT BE ACCEPTED

Please Send Permit Applications to:

NWHI State Marine Refuge Permit Coordinator State of Hawai'i Department of Land and Natural Resources Division of Aquatic Resources 1151 Punchbowl Street, Room 330 Honolulu, Hawai'i 96813
NWHI State Marine Refuge Permit Application See Appendix 2 for Application Instructions

Section A – Applicant Information	
1. Project Leader (attach Project Leader's CV or resume) CV attached Name: Last, First, Middle Initial **Meyer, Carl, G.**	Title: **Assistant Researcher**
2. Mailing Address (Street/PO Box, City, State, Zip) : **PO Box 1346, Kaneohe, Hawaii, 96744**	Telephone ( ) Fax ( ) Email Address: **Telephone (808) 236-7477** **Fax (808) 236-7443** **Email Address carlm@hawaii.edu**

3. Affiliation (Institution/Agency/Organization)	For graduate students, Major Professor 's Name & Telephone
Hawaii Institute of Marine Biology, University of Hawaii	
4. Sub-Permittee/Assistant Names, Affiliations, and Contact Information CV or resume attached	
Pedro Santos, Zoology Department, University of Hawaii	
5. Project Title **Movements of Top Predators along the Hawaiian Archipelago**	
6. Applicant Signature 	7. Date (mm/dd/yyyy) **03/07/2006**

Section B: Project Information

8. **(a) Project Location**

- **X** NWHI State Marine Refuge (0-3 miles) waters surrounding:
- **X** Nihoa Island
- **X** French Frigate Shoals
- **X** Gardner Pinnacles

Describe project location (include names, GPS coordinates, habitats, depths and attach maps, etc. as appropriate).

We are investigating movements of top predators along the Hawaiian archipelago and beyond. This permit application is for research activities to be carried out at Nihoa, French Frigate Shoals & Gardner Pinnacles in May & June 2006 as part of this larger project. We plan to capture and tag top predators at Nihoa, French Frigate Shoals & Gardner Pinnacles. We also aim to download existing underwater receivers at French Frigate Shoals (Table 1), and deploy new receivers at Nihoa & Gardner Pinnacles (Table 2).

Table 1. Current receiver deployment locations at FFS.

Atoll	Location	Latitude	Longitude	Depth (ft)
FFS	East Island	23.78686000	-166.20709000	10
FFS	La Perouse	23.76945000	-166.26208333	30
FFS	Tern Island	23.86664000	-166.28820000	15
FFS	Trig Island	23.86945278	-166.24158333	10
FFS	Rapture Reef	23.63509000	-166.18570000	85

Table 2. Proposed receiver deployment locations for the May 2006 NOAA/NWHICRER research cruise.

Atoll	Location	Latitude	Longitude	Depth (ft)
Gardner Pinnacles	East side of Main Pinnacle	24.99883	-167.99958	10
Nihoa	S. Nihoa	23.02152	-161.93482	45

(b) check all actions to be authorized:

We request authorization to enter the NWHI Marine Refuge waters, observe, catch, tag & release snappers & sharks, deploy small underwater receivers on temporary moorings.

(c) Collection of specimens – collecting activities (would apply to any activity): Organisms or objects (List of species, if applicable, add additional sheets if necessary):

Common name	Scientific name	No. & size of specimens	Collection Location(s)
Tiger shark	*Galeocerdo cuvier*	10 (2.5-5 m Total Length)	FFS, Nihoa
Gray reef shark	*C. amblyrhynchos*	7 (1.2 – 2.4 m Total Length)	FFS, Nihoa
Whitetip reef shark	*T. obesus*	10 (1.0-1.7 m Total Length)	FFS
Grey snapper	*Aprion virescens*	10 (0.5-1.2 m Total Length)	Nihoa

(d) What will be done with the specimens after the project has ended?
Sharks & snappers will be captured and released immediately after measuring and transmitter attachment.

(e) Will the organisms be kept alive after collection?
Sharks & snappers will be captured and released immediately after measuring and transmitter attachment.

(Please attach additional documentation as needed to complete the questions listed below)

9. Purpose/Need/Scope: • State purpose of proposed activities:

The purpose of our proposed activities is to determine how widely top predators range in the Northwestern Hawaiian Islands, and whether their movements are predictable. We are testing the following null hypotheses;

H1: Top predators do not move across open ocean between NWHI atolls
H2: Top predators are not wide-ranging within individual atolls
H3: Top predators do not exhibit predictable patterns of movement and habitat use

Describe how your proposed activities will help provide information or resources to fulfill the State Marine Refuge purpose and to reach the Refuge goals and objectives. • Give reasons why this activity must take place in the NWHI and cannot take place in the Main Hawaiian Islands, or elsewhere.

We will provide empirical data on top predator movements that will be valuable for developing appropriate management strategies for these ecologically important animals. The questions that we are addressing are directly pertinent to management of NWHI resources (this component of our study involves quantifying movements of top predators captured within the NWHI), hence the study must be carried out in the NWHI. It would not be feasible to conduct this component of our study outside the NWHI.

• Describe context of this activity, include history of the science for these questions and background.

Top predators play a keystone role in many ecosystems and in the Northwestern Hawaiian Islands (NWHI) this role is filled by sharks (primarily *Galeocerdo cuvier*, *Carcharhinus galapagensis*, *Carcharhinus amblyrhynchos* and *Triaenodon obsesus*) and large teleost fishes (primarily *Caranx ignobilis*) (DeCrosta 1981, Wetherbee et al. 1997, Friedlander & DeMartini 2002, DeMartini et al. 2005). Previous NWHI studies have quantified top predator age and growth (Parrish et al. 1980, DeCrosta 1981, Sudekum et al. 1991,), reproduction (Parrish et al. 1980, Sudekum et al. 1991, Wetherbee et al. 1997), diet and trophic interactions (Sudekum et al. 1991, Wetherbee et al. 1997), and spatial distribution and abundance (Wetherbee et al. 1997, Friedlander & DeMartini 2002, DeMartini et al. 2005). The movement patterns of top predators in the NWHI have received far less attention with previous scientific studies limited to short-term (<48h) acoustic tracks of 3 *G. cuvier* at French Frigate Shoals (Tricas 1981, Lowe et al. in press) and longer term acoustic monitoring of tiger sharks (N=14), *C. galapagensis* (N=10) and *C. ignobilis* (N=3) at French Frigate Shoals and Midway.

We are currently quantifying the movements of ecologically important and commercially valuable top predators in the NWHI, and addressing 3 questions relevant to management zoning; (1) Do top predators move across open

ocean between atolls?, (2) How extensive are their intra-atoll movements?, and (3) Do top predators exhibit predictable patterns of movement and habitat use? In 2005 we equipped 107 top predators (6 species) with surgically-implanted acoustic transmitters and monitored their subsequent movements using 18 underwater receivers stationed on the seabed at 5 atolls in the NWHI. Using this system we obtained the first empirical evidence that gray reef sharks (*Carcharhinus amblyrhynchos*) move across open ocean between atolls (Meyer et al. submitted[1]), and found that all 6 top predator species investigated were wide-ranging within individual atolls. We also found that several species exhibited predictable patterns of movement, including diel habitat shifts and lunar rhythmicity (Meyer et al. submitted[2]). We propose to continue this research in order to provide additional empirical fish movement data that will assist NWHI resource managers to assess the potential impact of different management strategies.

• Explain the need for this activity and how it will help to enhance survival or recovery of refuge wildlife and habitats.

We need to know how far coral reef top predators range over months or years in order to design refuges that contain appropriate habitat types and are large enough to provide effective, long-term protection for these animals. Despite this basic design requirement and the burgeoning popularity of 'no fishing' Marine Protected Areas (MPAs) as coral reef management tools, empirical data quantifying long-term movement patterns and space requirements of coral reef fishes & sharks remain scarce (Roberts & Polunin 1993; Nowlis & Roberts 1999; Kramer & Chapman 1999; Sadovy et al. 2003; Gerber et al. 2005; Meyer & Holland 2005). We will provide empirical top predator movement data that will enable resource managers to optimize conservation strategies for these animals. A good example of this is our recent discovery that an adult female gray reef shark swam 266 km from Kure Atoll to Pearl & Hermes Reef (crossing several management jurisdictions). This is the first time that a gray reef shark has been empirically shown to cross open-ocean and the scale of this journey has significant implications for management of these sharks which are being increasingly targeted by the lucrative shark fin trade (Raloff 2002).

• Describe how your proposed project can help to better manage the State Marine Refuge.

We are addressing questions that are directly relevant to the design of effective Marine Protected Areas (a cornerstone of the ecosystem approach to management). The NWHI provide an ideal opportunity to quantify long-term movement patterns and space utilization of coral reef top predators in a largely unexploited environment, and to evaluate the minimum MPA size required for effective long-term protection of these large animals. Our research in the NWHI is providing empirical data that are valuable for State Marine Refuge management and that can also be used to evaluate management strategies for coral reef top predators in other, populated areas where large MPAs are not feasible because of social resistance (Meyer et al. submitted[1]).

10. Procedures (include equipment/materials)

(1) Deployment of underwater receivers
We will create temporary receiver moorings at the sites described in Table 2 (Section 8 above) using a system that has previously been empirically demonstrated to successfully withstand seasonal high surf. Moorings will consist of sand screws in areas of soft sediment, and chain around inert substrate in hard bottom areas (live substrates will be avoided). We will remove these moorings when acoustic monitoring is completed (receivers will be in place for at least 2 years). The receivers will be anchored to the moorings and suspended 1-2 m above the ocean floor. The receivers will identify and record the presence of any acoustic transmitters within range (up to 500 m). The transmitter number, time of arrival and departure and the date will be recorded and stored until the data are downloaded from the receivers to a computer. The receivers have a battery life of approximately 15 months and will be serviced at 6 to 12 month intervals.

(2) Deployment of transmitters
We will tag 4 species of top predator, including 3 sharks and 1 teleost, at several locations within the NWHI (Table 3). We chose these species because they are thought to represent a broad spectrum of mobility patterns, ranging from highly site attached to extremely wide ranging (Randall 1977, Holland et al. 1996, Holland et al. 1999, 2001, Wetherbee et al. 1996, 1997, 2004, Meyer & Honebrink 2005, Lowe et al. in press). We have already tagged 107 of these animals in the NWHI, and our proposed tagging effort for the May 2006 cruise is designed to enable us to meet our original sample size objectives. We will double tag individual sharks with acoustic & satellite transmitters to minimize the total number of top predators tagged.

Table 3. Predator species selected for tagging with acoustic & satellite transmitters.

Scientific Name	Major Prey Groups	Location & Number of Animals
Galeocerdo cuvier	Fishes, sharks, reef invertebrates, turtles, marine mammals	Nihoa (5), FFS (5),
Carcharhinus amblyrhynchos	Reef fishes, reef invertebrates	Nihoa (5), FFS (2),
Triaenodon obesus	Reef fishes, reef invertebrates	FFS (10)
Aprion virescens	Reef fishes	Nihoa (10)

Our predator handling & tagging activities will be carried out in accordance with the animal use protocols of the University of Hawaii (protocol #05-053). We will capture target species by trolling (towing an artificial lure), handlining (using a single baited hook) from a small skiff and a bottom set 6 hook line (for large sharks). Captured shark species will be brought alongside the skiff, tail-roped and inverted to initiate tonic immobility. In this trance-like condition, sharks remain docile while transmitters are surgically implanted. Teleosts will be placed into a cradle and inverted for transmitter implantation. We will implant coded acoustic transmitters (V16, 9 mm diameter, 90 mm long, Vemco, Halifax, Nova Scotia) into the body cavities of each animal through a small incision in the abdominal wall (Holland et al., 1999; Meyer & Honebrink 2005). The incision will be sutured closed. Our acoustic transmitters have expected life spans of over two years, thereby offering the possibility of detecting annual or seasonal patterns of movement and habitat use.

We will also equip 10 sharks (5 tiger sharks & 5 gray reef sharks) with satellite transmitters following acoustic transmitter implantation. We will use two types of satellite transmitters; (1) Fin mounted fixed transmitters (SPOT tags, 41 mm x 30 mm x 17 mm, weight 32 g, Wildlife Computers, Seattle), and (2) Pop-up archiving tags (PAT tags, length 180 mm, positively buoyant in water, Wildlife Computers, Seattle). SPOT tags transmit the shark's location to the Argos satellite array whenever the dorsal fin breaks the surface of the water. PAT tags collect and store temperature, depth & light intensity data as the shark swims, and then detach from the animal on a preprogrammed date & time. The released PAT tags float to the surface where they transmit archived data to the Argos satellite array. We will attach the SPOT tags by using a template to make two small (3 mm diameter) holes near the tip of the shark's dorsal fin, pushing short, threaded rods extending from the transmitter through these holes, and then securing the device on the opposite side of the fin with washers & bolts. We will attach PAT tags using small titanium-steel darts that are inserted under the shark's skin at the base of the dorsal fin and locked in place through the dorsal ceratotrichia. Following transmitter attachment we will remove the hook and release the animal. The entire handling process can be completed in less than 10 minutes.

(3) Data retrieval, reduction and analysis.
Satellite transmitters: Data transmitted by our satellite tags will be emailed to us each month.

Acoustic transmitters: We will download receivers currently deployed at French Frigate Shoals (Table 3) during the May 2006 cruise. Data downloading consists of interfacing the receiver to a computer via a magnetically coupled probe and the serial port of the computer, and can be accomplished in the field. Preliminary data reduction and analyses will commence onboard the ship after downloading.

11. Funding sources (attach copies budget & funding sources).

This research is funded by an award from the National Marine Sanctuaries Program (NMSP MOA 2005-008/66882).

12. List all literature cited in this application as well as all other publications relevant to the proposed project.

DeCrosta MA (1981). Age determination and growth of three species of shallow-water carcharhinid sharks in Hawaii. Pacific Science 35:266-267.

DeMartini EE, Friedlander AM and SR Holzwarth (2005). Size at sex change in protogynous labroids, prey body size distributions, and apex predator densities at NW Hawaiian atolls. Marine Ecology Progress Series 297: 259–271.

Friedlander AM and EE DeMartini (2002). Contrasts in density, size, and biomass of reef fishes between the

northwestern and the main Hawaiian islands: the effects of fishing down apex predators. Marine Ecology Progress Series 230:253-264.

Gerber LR, Heppell SS, Ballantyne F, and E Sala (2005). The role of dispersal and demography in determining the efficacy of marine reserves. Canadian Journal of Fisheries and Aquatic Sciences 62:863-871.

Holland KN, Lowe CG and BM Wetherbee (1996). Movements and dispersal patterns of blue trevally (Caranx melampygus) in a fisheries conservation zone. Fisheries Research 25: 279-292.

Holland, KN, AC Bush, CG Meyer, SM Kajiura, BM Wetherbee & CG Lowe (2001). Five tags applied to a single species in a single location: the tiger shark experience. pp. 237-247 in JR Sibert & JL Nielsen, eds. Electronic tagging and tracking in marine fisheries. Kluwer Academic Publishers, The Netherlands.

Kramer DL & MR Chapman (1999). Implications of fish home range size and relocation for marine reserve function. Environmental Biology of Fishes 55:65-79.

Lowe CG, Wetherbee BM, Crow GL & AL Tester (1996) Ontogenetic dietary shifts and feeding behavior of the tiger shark, Galeocerdo cuvier, in Hawaiian waters. Environmental Biology of Fishes 47:203-211.

Lowe CG, Wetherbee BM & CG Meyer (In Press). Using acoustic telemetry monitoring techniques to quantify movement patterns and site fidelity of sharks and giant trevally around French Frigate Shoals and Midway Atoll. Atoll Research Bulletin.

Meyer CG and KN Holland. (2005). The role of movement patterns, home range size and site fidelity in greater abundance and size of bluespine unicornfish (Naso unicornis; Acanthuridae) in a small marine reserve. Environmental Biology of Fishes 134:602-606.

Meyer, CG & R Honebrink. 2005. Retention of surgically implanted transmitters by bluefin trevally (Caranx melampygus). Implications for long-term movement studies. Transactions of the American Fisheries Society. 134:602-606.

Meyer CG, Papastamatiou YP & KN Holland (Submitted[1]). Ocean journey by a grey reef shark (Carcharhinus amblyrhynchos). Biology Letters.

Meyer CG, Holland KN & YP Papastamatiou (Submitted[2]). Can small Marine Protected Areas protect coral reef top predators? Empirical data from giant trevally (Caranx ignobilis) at remote Hawaiian atolls. Conservation Biology.

Nowlis JS and CM Roberts (1999). Fisheries benefits and optimal design of marine reserves. Fishery Bulletin 97:604-616.

Parrish J, Taylor L, DeCrosta M, Feldkamp S, Sanderson L and C Sorden (1980).
Symposium on Status of Resource Investigations in the Northwestern Hawaiian Islands. pp. 175-188.

Raloff J (2002). Clipping the Fin Trade. Science News 162: 232

Randall JE (1977). Contribution to the biology of the whitetip reef shark (Triaenodon obesus). Pacific Science 31:143-164.

Roberts CM and NVC Polunin. (1993). Marine reserves: Simple solutions to managing complex fisheries? Ambio 22:363-368.

Sadovy Y, Kulbicki M, Labrosse P, Letourneur Y, Lokani P, and TJ Donaldson (2003). The Humphead Wrasse, Cheilinus undulatus: Synopsis of a Threatened and Poorly Known Giant Coral Reef Fish. Reviews in Fish Biology and Fisheries 13:327-364.

Sudekum AE, Parrish JD, Radtke RL and S Ralston (1991). Life history and ecology of large jacks in undisturbed, shallow, oceanic communities. Fishery Bulletin 89: 493-513.

Tricas TC, Taylor LR and G Naftel. (1981). Diel behavior of the tiger shark, Galeocerdo cuvier, at French Frigate Shoals, Hawaiian Islands. Copeia 1981:904-908.

Wetherbee BM, Crow GL and CG Lowe. (1996). The biology of the Galapagos shark, Carcharhinus galapagensis, in Hawaii. Environmental Biology of Fishes. 45:299-310.

Wetherbee BM, Crow GL and CG Lowe (1997). Distribution, reproduction and diet of the gray reef shark Carcharhinus amblyrhynchos in Hawaii. Marine Ecology Progress Series 151: 181-189.

Wetherbee, BM, KN Holland, CG Meyer and CG Lowe. (2004). Use of a marine reserve in Hawaii by the giant trevally, Caranx ignobilis. Fisheries Research 67:253-263.

13. What types of insurance do you have in place? (attach documentation) Wreck Removal Pollution

NOAA Ship HI`IALAKAI is a U.S. Government-owned and –operated research vessel and is self-insured by the U.S. Government.

14. What certifications/inspections do you have scheduled for your vessel? (attach documentation) Rat free tender vessel gear/equipment Hull inspection ballast water

- Rat Free (scheduled with U.S. Dept. of Health and Human Services for April 2006)
- Hull Inspection (scheduled with Hawaii Institute of Marine Biology biologists (normally Scott Godwin) prior to projects working in the Northwestern Hawaiian Islands (NWHI)) to ensure no nuisance algae or other fouling species are transported to the NWHI.
- Ballast water information is transmitted to USCG as required by CFR Title 33, Vol. 2, Parts 151.1500 to 199; IMO Resolution A.868(20); and USCG COMDTPUB P16700.4

15. Other permits (list and attach documentation of all other required Federal or State permits).

US-FWS & NWHI-CRER permits pending

16. Project's relationship to other research projects within the NWHI State Marine Refuge, National Wildlife Refuge, NWHI Coral Reef Ecosystem Reserve, or elsewhere.

We are also quantifying movements of sharks and reef fishes in the Main Hawaiian Islands using the same technologies, and have an archipelago wide array of listening stations (Kure Atoll to Kona, Hawaii).

Section C: Logistics

17. Time Frame:

Project Start Date	**Project Completion Date**
May 2005	September 2007

Dates actively inside the State Marine Refuge.

May 19 thru June 7, 2005

Personnel schedule in the State Marine Refuge (describe who will be where and when).

Carl Meyer & Pedro Santos will be carrying out research activities described above on the NOAA-NWHICRER Hi'ialakai cruise scheduled to visit the NWHI & Johnston Atoll between May 18 & June 9 2006;
Nihoa (May 19, 20, 21)
FFS (May 22, 23, 24, 25, 26)
Gardner Pinnacles (May 27, 28)
Johnston (June 1, 2, 3, 4, 5, 6)

18. Gear and Materials Dive equipment Radio Isotopes Collecting Equipment Chemicals (specify types)

Our research gear will include scuba diving equipment, fishing equipment, acoustic receivers (deployed on the sea bed), and acoustic & satellite transmitters (deployed on sharks & fishes). Non-deployed equipment will be transported in and out of the NWR on the NOAA vessel Hi'ialakai.

19. Fixed installations and instrumentation. Transect markers Acoustic receivers Other (specify)

We will be deploying & servicing underwater receivers, and deploying acoustic & satellite tags. The protocol for these deployments is detailed in section 10 (Procedures).

20. Provide a time line for sample analysis, data analysis, write-up and publication of information.

Analyses & interpretation of data are ongoing. We have already submitted 2 manuscripts describing our 2005 findings to international peer reviewed journals, and presented our data at a recent international ocean science conference.

21. **Vessel Information:**

Vessel Name – NOAA Ship HI`IALAKAI
IMO Number – 8835619
Vessel Owner – U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration (NOAA)
Flag – USA
Captain's Name – CDR Scott Kuester, NOAA
Chief Scientist or Project Leader – Randall Kosaki, Ph.D., NOAA
Vessel Type – Oceanographic Research
Call Sign – WTEY
Length – 224 feet
Gross Tonnage – 1,914
Port of Embarkation – Honolulu
Last port vessel will have been at prior to this embarkation – Pago Pago, Amer. Samoa
Total Ballast Water Capacity:
Volume – 487 m3 (128,834 U.S. gal.)
Total number of ballast tanks on ship – 10
Total Fuel Capacity:
228,642 U.S. gal. at 98% capacity
Total number of fuel tanks on ship – 15
Other fuel/chemicals to be carried on board and amounts: gasoline – as much as 700 U.S. gal.; lube oil – as much as 10,442 U.S. gal.; numerous other industrial and household chemicals used to operate a 224-foot research vessel
Number of tenders/skiffs aboard and specific type of motors:

Ship's own tenders - 1 each 10 m AMBAR Marine jet boat with Yanmar 370-hp, Diesel inboard engine
1 each 8 m AMBAR Marine jet boat with Yanmar 315-hp, Diesel inboard engine
2 each 17.5 ft Zodiac inflatable boats, each with one Honda 50-hp, 4-stroke, outboard gasoline engine
1 each 19 ft AMBAR Marine rescue boat with Honda 115-hp, 4-stroke, outboard gasoline engine

Program-provided tenders – 19' Boston Whaler with 135 hp Honda four-stroke outboard

Does the vessel have the capability to hold sewage and grey-water? Describe in detail. The ship has a 4,000 U.S. gal Collection Holding Tank for sewage and grey water. In those waters where effluent may NOT be discharged, sewage and grey water are held in this tank until the ship is in waters where sewage and grey water may be discharged. The ship has a U.S. Coast Guard-approved Marine Sanitation Device (Omnipure model MSD 12 MC) which is used to treat sewage and grey water in those waters where effluent may be discharged.

Does the vessel have a night-time light protocol for use in the NWHI? Describe in detail. Navigation lights are on

24-hours/day. Work lights are put on at night only when conducting CTD operations. Weather decks are not illuminated at night.
On what workboats (tenders) will personnel, gear and materials be transported within the State Marine Refuge? Personnel, gear and materials may be transported within the State Marine Refuge by the ship or any of the 5 ship's small boats listed above or by the program-provided small boat listed above.
How will personnel, gear and materials be transported between ship and shore? Personnel, gear and materials may be transported between ship and shore by any of the 5 ship's small boats listed above or by the program-provided small boat listed above.
If applicable, how will personnel be transported between islands within any one atoll? Personnel may be transported between islands within any one atoll by any of the 5 ship's small boats listed above or by the program-provided small boat listed above.

CURRICULUM VITAE
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TITLES

Assistant Researcher, Hawaii Institute of Marine Biology, University of Hawaii.

EDUCATION

Ph.D. (*Zoology*), University of Hawaii at Manoa. "Evaluating the effectiveness of small marine reserves. Waikiki Marine Life Conservation District as a case study.", 2003. Advisor: Dr. Kim Holland.

M.Phil. (*Biological Sciences*), University of Plymouth, England. "Biology and fishery of the spider crab, *Maja squinado*, around Jersey (Channel Islands)", 1993. Advisor: Dr. Malcom Jones.

B.Sc. Hons. (*Biological Sciences*), University of Plymouth, England, 1990. Advisor: Dr. Peter Reay.

GRANTS AND AWARDS

2005-2006 **NOAA General Coral Reef Conservation Grant**: Acoustic monitoring of long-term movement patterns, habitat use and site fidelity of coral reef fishes: Implications for Marine Protected Area design (P.I.: $28,750).

2005-2006 **Hawaii Sea Grant Program**: Foraging ecology and movement patterns of blacktip reef sharks at Palmyra atoll (P.I.: $9.975).

2001 University of Hawaii, **26th Annual Albert L. Tester Memorial Symposium**, Best Student Paper Award.

RESEARCH EXPERIENCE

Assistant Researcher. *University of Hawaii, Joint Institute for Marine and Atmospheric Research.* August 2003 – Present.

- 2005 Ultrasonic tagging study of marine apex predator movements in the Northwest Hawaiian Islands.
- 2003-2005 Experimental investigation of the shark compass sense.
- 2003-2005 Research and development of new electronic telemetry tags.
- 2003-2005 Ultrasonic tagging study of tiger shark movements in Hawaii.

Collaborator. *Hawaii Division of Aquatic Resources Ulua Tracking Project.* 2003-2004.

- Acoustic monitoring study of jack (Carangidae) movements in West Hawaii.

Research Assistant. *University of Hawaii, Hawaii Institute of Marine Biology.* 1993-2003.

- 2001- 2003 Quantified human activities and impacts in four Hawaii Marine Protected Areas using a novel Geographic Information System (GIS) approach.
- 1997-2001 Conducted underwater visual censuses of reef fish populations in and around Waikiki marine reserve.
- 1999-2001 Quantified fishing and other marine recreational activities along the Kewalo-Waikiki-Diamond Head shoreline (south coast of Oahu, Hawaii).
- 1997-2001 Quantified movement patterns, home range sizes, habitat use and dispersal of reef fishes in Waikiki Marine Life Conservation District (a no-fishing marine reserve) using ultrasonic and conventional identification tags.
- 1993-2001 Assisted with shark long lining, tagging and ultrasonic tracking around the Main Hawaiian Islands.
- 1995-1996 Collected gonads and otoliths from commercially targeted coral reef fishes around Oahu.
- 1993-1996 Assisted with reef fish tagging and tracking around Coconut Island (Kaneohe Bay, Oahu).
- 1993-1995 Collected diet data from jacks captured during three annual recreational fishing tournaments designed to gather scientific data.

Collaborator. *French Frigate Shoals Tiger Shark Research Project.* 1999-2003.

- Participated in acoustic monitoring study of tiger shark behavior at French Frigate Shoals Atoll.

Fisheries Biologist. *Department of Agriculture and Fisheries, Jersey (Channel Islands).* 1990 – 1993.

- 1992-1993 Assisted with design and implementation of fishing licensing scheme for local fishing fleet. Carried out survey of commercial and recreational fishing activities.
- 1992 Organized First International Majid Crab Conference.
- 1990-1993 Mapped nursery areas and elucidated juvenile life history of spider crabs (*Maja squinado*).
- 1991-1993 Experimentally tested size selectivity and discard damage rates of spider crab tangle nets.

- 1990-1993 Quantified catch and effort in the commercial spider crab fishery, and participated in spider crab stock assessment cruise.

- 1992-1993 Compared effectiveness of different methods of measuring minimum legal size (MLS) of European lobsters (*Homarus gammarus*).

Undergraduate honors project – *University of Plymouth, England*

- 1988-1989 Quantified vertical distribution and habitat preferences of intertidal fishes in Jersey (Channel Islands).

PUBLICATIONS

1. Peer Reviewed

Lowe C.G., B.M. Wetherbee and **C.G. Meyer**. Accepted. Using acoustic telemetry monitoring techniques to quantify movement patterns and site fidelity of sharks and giant trevally around French Frigate Shoals and Midway Atoll. ***Atoll Research Bulletin***

Meyer, C.G. and K.N. Holland. 2005. The role of movement patterns, home range size and site fidelity in greater abundance and size of bluespine unicornfish (*Naso unicornis*; Acanthuridae) in a small marine reserve. ***Environmental Biology of Fishes*** 134 (3): 602-606.

Meyer, C.G. & R Honebrink. 2005. Retention of surgically implanted transmitters by bluefin trevally (*Caranx melampygus*). Implications for long-term movement studies. ***Transactions of the American Fisheries Society*** 134: 602-606.

Meyer, C.G., Holland, K.N. & Y.P. Papastamatiou. 2005. Sharks can detect changes in the geomagnetic field. ***Journal of the Royal Society Interface*** 2: 129–130.

Wetherbee, B.M., K.N. Holland, **C.G. Meyer** and C.G. Lowe. 2004. Use of a marine reserve in Hawaii by the giant trevally, *Caranx ignobilis*. ***Fisheries Research*** 67:253-263.

Meyer, C.G. and K.N. Holland. 2001. A kayak method for tracking fish in very shallow water. ***Reviews in Fish Biology and Fisheries***. *In:* J.R. Sibert and J. Nielsen (Eds.), Electronic Tagging and Tracking in Marine Fisheries (pp. 289-296). Kluwer Academic Publishers, The Netherlands.

Holland, K., A. Bush, **C. Meyer**, S. Kajiura, B. Wetherbee, and C. Lowe. 2001. Five tags applied to a single species in a single location: The tiger shark experience. ***Reviews in Fish Biology and Fisheries***. *In:* J.R. Sibert and J. Nielsen (Eds.), Electronic Tagging and Tracking in Marine Fisheries (pp. 237-248). Kluwer Academic Publishers, The Netherlands.

Meyer, C.G., K.N. Holland, B.M. Wetherbee, and C.G. Lowe. 2001. Diet, resource partitioning and gear vulnerability of Hawaiian jacks captured in fishing tournaments. ***Fisheries Research*** 53:105-113.

Meyer, C.G., K.N. Holland, B.M. Wetherbee, and C.G. Lowe. 2000. Movement patterns, habitat utilization, home range size and site fidelity of whitesaddle goatfish (*Parupeneus porphyreus*) in a marine reserve. ***Environmental Biology of Fishes*** 59: 235-242.

Holland, K.N., B.M. Wetherbee, C.G. Lowe and **C.G. Meyer**. 1999. Movements of tiger sharks (*Galeocerdo cuvier*) in coastal Hawaiian waters. ***Marine Biology*** 134: 665-675.

2. Technical Reports

Holland, K.N. and **C.G. Meyer**. 2003. Human Activities in Marine Protected Areas - Impact on Substrates. Final Report. Honolulu, HI: Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, 37 pp

Holland, K.N. and **C.G. Meyer**. 2002. Hawaii Marine Protected Areas Usage Survey – Final Report. Honolulu, HI: Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, 20 pp

Holland, K.N. and **C.G. Meyer**. 2002. Fishing Activity and its Impact on the Efficacy of Marine Protected Areas. Final Report. Hawaii Coral Reef Initiative, 8pp

Meyer, C.G. and S. M. Clark. 2000. A preliminary analysis of human activity patterns in the Waikiki Fisheries Management Area and Marine Life Conservation District. Final Report. Honolulu, HI: Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii, 20 pp

Meyer, C.G. and K.N. Holland. 1996. Harvest refugia as fisheries management tools: empirical data on fish movement patterns, habitat use and dispersal. Proceedings of the Western Association of Fish and Wildlife Agencies 76: 200-207.

Meyer, C.G. 1992. Seasonal variation in composition of trap catches of the spider crab (*Maja squinado*, Herbst, 1788) in a known inshore nursery area on the south coast of Jersey (British Channel Islands). International Council for the Exploration of the Sea, Copenhagen (Denmark). Shellfish Committee Meeting Papers. 10 pp.

Bossy, S.F., Le Blancq, D.J. and **Meyer, C.G.** 1992. A comparison between the use of total length and carapace length for measuring the minimum legal landing size for the European lobster (*Homarus gammarus* L.). International Council for the Exploration of the Sea, Copenhagen (Denmark). Shellfish Committee Meeting Papers. 3 pp.

3. Book Chapters

Meyer, C.G. 2001. A day in the life of a marine biologist. pp 18-19 In: Ocean Watch. Dorling Kindersly Publishing Inc., New York, NY.

Holland, K.N., C.G. Lowe, B.M. Wetherbee, A.C. Bush and **C.G. Meyer**. 1998. Sharks and people. pp. 124-153 In: Sharks. Reader's Digest Association, Pleasantville, NY.

REVIEWER

Aquatic Living Resources
California Sea Grant
Caribbean Journal of Science
Environmental Biology of Fishes
Fisheries Research
Hawaii Academy of Science
Journal of Fish Biology
Journal of Shellfish Research
Marine and Freshwater Research
Marine Biology
Marine Ecology Progress Series
National Science Foundation

INVITED PRESENTATIONS

2005 *Using GIS to Assess Marine Reserve Effectiveness*, California State University at Long Beach.

2004 *Evaluating the Effectiveness of Small Marine Reserves*, Leeward Community College, Hawaii.

2004 *Shark movement patterns in the Hawaiian Islands*, Hawaii Sharks Teachers Conference, Hawaii Institute of Marine Biology.

2003 *Reef Fish Movements & Habitat Use*, Hawaii Coral Reef Fishery Management Workshop.

2001 *Tiger shark research in Hawaii*, Hawaii Annual Ocean Safety Conference.

2001 *Why we need marine reserves*, Malama Ohana, Hawaii.

2001 *Reef Fish Migrations*, Waikiki Aquarium, 2001

ADVISORY POSITIONS

Scientific Advisor - Pupukea Marine Life Conservation District task force, 2001-2002.

Participant - Hawaii Marine Protected Area working group, 2002-2003.